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DESTROYER ENGINEERED OPERATING CYCLE (DDEOC)

System Maintenance Engineering Analysis (SMEA) DD-963 CLASS 60/400 HZ POWER CONVERSION AND DISTRIBUTION SYSTEM SWAB GROUPS 314-4, 324-1, and 324-4

SMEA 963-314/324

REVIEW OF EXPERIENCE

September 1980

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Prepared for
Director, Escort and Cruiser Ship Logistic Division
Naval Sea Systems Command
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This report documents the historical and predicted maintenance experience for the DD-963 Class 60/400 Hz static frequency conversion and distribution system, SWAB groups 314-4, 324-1, and 324-4. It presents an analysis of the existing maintenance policy and the maintenance problems encountered and recommends specific actions and maintenance policy modifications to improve equipment availability, reliability, and maintainability.

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FOREWORD

This report documents the historical and predicted maintenance experience for the DD-963 Class 60/400 Hz static frequency conversion and distribution system, SWAB groups 314-4, 324-1, and 324-4. It presents an analysis of the existing maintenance policy and the maintenance problems encountered and recommends specific actions and maintenance policy modifications to improve equipment availability, reliability, and maintainability. This report was developed for NAVSEA 931X, the Manager of the Destroyer Engineered Operating Cycle (DDEOC) Program, under Navy Contract N00024-79-C-4230.

SUMMARY

The goal of the Destroyer Engineered Operating Cycle (DDEOC) Program is to effect an early improvement in the material condition of ships at an acceptable cost while maintaining or increasing their operational availability during an extended operating cycle. In support of this goal, system maintenance engineering analyses (SMEAs) are being conducted on those DD-963 Class systems and subsystems which have historically exhibited relatively high maintenance burdens. This report documents the SMEA for the DD-963 Class 60/400 Hz frequency conversion and distribution system, ships work authorization boundary (SWAB) groups 314-4, 324-1, and 324-4.

The SMEA is an analysis of (1) the impact of the historical and anticipated corrective maintenance requirements that affect the operational performance and maintenance programs of a ship system, and (2) the significance of these maintenance requirements to the DDEOC Program. This report documents the results of the SMEA and presents the recommended system maintenance policy and specific maintenance actions best suited to meet DDEOC goals.

The SMEA for the equipment included an examination of all available maintenance data sources. The documented maintenance experience of the systems was identified by review and analysis of data from the maintenance data system (MDS) and casualty reports (CASREPs), as well as by examination of the DD-963 Class plans for maintenance (PFMs) and maintenance engineering analyses (MEAs). Initial findings from these sources were correlated with current planned maintenance system (PMS) requirements, existing and planned system alterations and class items, and system technical manual data. Ship surveys were conducted and discussions were held with appropriate technical personnel within Naval Sea Systems Command (NAVSEA) and with the in-service engineering agent (ISEA) to validate identified maintenance requirements, to identify undocumented maintenance requirements, and to determine the status of current and planned actions affecting the equipment. All findings were evaluated, and appropriate conclusions were developed.

A system maintenance policy was developed on the basis of these conclusions. Recommendations were then formulated to implement the policy by periodically accomplishing specific maintenance actions. These actions are documented in this report and are included as tasks

in the DD-963 Class maintenance plan. Also documented, as appropriate, are recommendations for improving system preventive maintenance; integrated logistics support; reliability, maintainability, and availability; and the capabilities of depot and intermediate maintenance activities (IMAs).

The major findings and conclusions of the SMEA for the DD-963 Class 60/400 Hz frequency conversion equipment are summarized as follows:

- The CV-3230/S 60/400 Hz solid-state frequency converters (SSFCs) in the DD-963 Class ships are not expected to perform satisfactorily during the operating cycle unless comprehensive improvements are made to the cooling systems and control circuitry for parallel operation of the converters.
- The current training course for the DD-963 Class 60/400 Hz power converter (A-652-0077) is inadequate and requires updating to include current equipment configuration as a result of multiple engineering changes on the equipment.
- The PMS program for the CV-3230/S SSFC as outlined on MIP EL-5/188 does not meet the equipment requirements as outlined in the equipment technical manual (NS-0962-077-4010) and MIP A-160/25 for electronic equipment cooling systems.
- Parts usage data indicate that the spare parts provisioning and shipboard allowable spares for the CV-3230/S SSFC are inadequate to support the equipments. A complete review of the APL (112700002C) is required to ensure that adequate support is provided during the operating cycle.
- Class B overhauls will be required on the CV-3230/S SSFC during ROH until this equipment is replaced under Shipalt DD-963-0247K.
- The input power and control circuitry wiring should be redesigned to provide power to the cooling water circulating pump at all times.
- Numerous INSURV discrepancies remain outstanding and require correction (see Appendix E).

Reliable operation of the equipment can be expected throughout an extended operating cycle if the dissimilar metals are removed from the equipment cooling system, the pure water filtration system is updated to meet MIL-STD-1399, and provisions are made in the equipment for parallel operation of the SSFCs. Specific recommendations resulting from the SMEA are presented in Chapter Four.

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CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

System maintenance engineering analyses (SMEAs) are being conducted on selected systems and subsystems of program-designated surface combatants in support of the Destroyer Engineered Operating Cycle (DDEOC) Program, managed by Naval Sea Systems Command (NAVSEA) 931X, in accordance with Contract N00024-79-C-4230. The SMEA is an analysis of the impact of the historical and anticipated corrective maintenance requirements that affect the operational performance and maintenance programs of a ship system. It serves as a vehicle for assessing the significance of these maintenance requirements to the DDEOC Program. The SMEA provides recommendations for specific maintenance actions and a system maintenance policy directed toward preventing or minimizing the impact of corrective maintenance while improving material condition and maintaining or increasing system availability throughout an extended operating cycle.

1.2 SCOPE

The analysis documented herein is specifically applicable to the DD-963 Class 60/400 Hz frequency conversion and distribution system, ships work authorization boundary (SWAB) groups 314-4, 324-1, and 324-4; it considers only systems and equipments installed and documentation effective as of 30 September 1979. The equipment was selected for analysis as a result of the findings of the Review of Existing Maintenance and Logistics Plans for DD-963 Class Ships, ARINC Research Publication 1663-02-1-2072, dated November 1979. The analysis used all available documented data sources from which system maintenance requirements could be identified and studied. These included maintenance data system (MDS) data, casualty reports (CASREPs), Board of Inspection and Survey (INSURV) reports, planned maintenance system (PMS) data, DD-963 Class plans for maintenance (PFMs) and maintenance engineering analyses (MEAs), system alteration and class item documentation, and system technical manuals. Sources of undocumented data used in this analysis included discussions with ships' forces and cognizant Navy technical personnel, including the in-service engineering agent (ISEA), which is the Naval Sea Systems Command (NAVSEA 5443).

1.3 REPORT FORMAT

The following chapters describe the analysis approach (Chapter Two), present the significant system maintenance experience and essential maintenance requirements (Chapter Three), and summarize the conclusions and recommendations derived from the analysis (Chapter Four). Specific data compilations that support the findings of the effort are included, as necessary, in the appendixes. A list of selected references precedes the appendixes.

CHAPTER TWO

APPROACH

2.1 OVERVIEW

This chapter describes the approach followed in performing the SMEA for the 60/400 Hz frequency conversion and distribution system, SWAB groups 314-4, 324-1, and 324-4. The systems were selected for analysis as a result of the findings of the Review of Existing Maintenance and Logistics Plans for DD-963 Class Ships, ARINC Research Publication 1663-02-1-2072, prepared for NAVSEA 931X. Data from sources identified in Section 1.2 were used to identify, define, and analyze maintenance requirements that will significantly affect the system's operational availability and material condition during an extended operating cycle. Recommendations for a maintenance strategy and implementation procedures were formulated on the basis of the analysis results. The major steps of the analysis were as follows:

- Relevant documented and undocumented maintenance data were compiled for the selected equipments or subsystems.
- These data were analyzed to identify and define recurring maintenance requirements that will significantly affect the equipments' operational availability and material condition during an extended operating cycle.
- An appropriate system maintenance strategy and the recommendations needed to implement it were developed and documented.

2.2 COMPILATION OF DATA

The analysis began with the compilation of data on the historical and predicted maintenance requirements of the system. The resulting data file consisted of four key elements: an MDS data bank, a CASREP narrative summary, a current and projected equipment-configuration summary, and a summary of expected future maintenance requirements. A library of appropriate technical manuals, PMS requirements, inspection reports, bulletins, and related documents was also assembled.

The MDS data bank was compiled by examining all MDS data reported for hulls DD-963 through DD-977 (15 ships) from September 1975 through September 1979. CASREP information was obtained by reviewing the CASREPs reported on the 60/400 Hz static frequency conversion and distribution

equipments during the data period September 1975 through November 1979. CASREPs resulting from the parts cannibalizations of equipments by other ships were not considered.

Configuration information was obtained by reviewing the type commanders' coordinated shipboard allowance lists (COSALs), shipalt records, engineering change proposal (ECP) records, MDS data, and the DD-963 Class items list and status. Ship visits also confirmed the current configuration of the equipment.

Predicted system maintenance requirements were identified by reviewing the available PFMs and MEAs for this system as well as the applicable PMS documentation. The maintenance requirements identified in these documents were reviewed and correlated with historical data to determine if their accomplishment will significantly affect equipment availability or material condition during an extended operating cycle. The PMS maintenance index pages (MIPs) and maintenance requirement cards (MRCs) used in this analysis were those in effect on 30 September 1979.

Historical overhaul data were not available for the DD-963 Class ships during this analysis. However, because many equipments on DD-963 Class ships are identical or similar to equipments installed in other ship classes, repairs historically accomplished during regular overhauls (ROHs) and complex overhauls (COHs) on those equipments were identified by reviews of historical repair profiles for other classes.

2.3 ANALYSIS OF MAINTENANCE DATA

Recurring maintenance requirements affecting the availability and material condition of 60/400 Hz frequency conversion and distribution equipment were identified by screening data obtained from the above-described sources and from ship surveys, discussions with Navy technical personnel, and NAVSEA special-interest programs.

MDS data provided the initial and primary source of information screened. The MDS data base included records of all part issues and labor transactions (such as narrative descriptions, cause codes, and when-discovered codes) reported against system equipments. The purpose of the initial screening process was to identify the historical maintenance actions that had been reported for the 60/400 Hz frequency conversion and distribution equipment.

The MDS part records and narratives were screened to identify those parts whose failure, as determined by the analyst, would cause instantaneous operational degradation of the equipment, or whose replacement would require the expenditure of a substantial number of man-hours. Parts so identified were then screened again to identify potential requirements for class-wide maintenance actions.

The appropriate PFMs and MEAs were screened to identify those system maintenance actions that would be required to correct failures that were anticipated but had not yet occurred or had not been shown by the data to be recurring. This process also identified maintenance that might be required to correct deficiencies resulting from age-related or operating-time-related failures.

When possible, the man-hour and parts burdens incurred for each equipment were quantified by means of computer-assisted analysis. Individual equipments or types of equipments that had contributed significantly to the systems' maintenance burden were identified as candidates for further analysis.

Computer-assisted analysis also rapidly identified those maintenance actions which were not or usually could not be completed by ships' forces and were deferred because outside assistance was required. Each identified maintenance action was then evaluated to determine the likelihood of its being required during an extended operating cycle. Maintenance requirements that were not likely to recur were eliminated from further consideration.

Further analysis was directed toward defining each recurring maintenance action in terms of several specific factors: the effect of the maintenance action on the subsystem or equipment, the interval between occurrences of the action, the redundancy of the affected subsystem or equipment, the criticality of the subsystem or equipment to mission accomplishment, the resources required to perform the necessary corrective maintenance, and the subsystem's or equipment's expected downtime.

Once the factors associated with the historically required maintenance actions were identified, the individual types of historical maintenance actions were analyzed to identify any design-related or maintenance-related problems that would have an impact on the selection of a maintenance strategy. Solutions were then sought by examining each problem in relation to the analysis criteria expressed in the following questions:

- Is the problem known to the Navy technical community, and has a solution been proposed or established?
- Will a design change reduce or eliminate the problem?
- Is the problem PMS-related? Can it be reduced or eliminated by changes to the PMS? (These changes might include adding or deleting requirements, changing periodicity, or developing material condition assessment tests and procedures.)
- Can the problem be reduced or eliminated by improving the system's integrated logistics support (ILS) at the ship's force level?
- Can the problem be reduced or eliminated by improving intermediate maintenance activity (IMA) or depot-level capabilities?
- Can the problem be reduced or eliminated by revising the existing maintenance strategy?

An affirmative answer to any question resulted in an analysis of the effects of the solution; a negative answer prompted the engineer to go to the next question. After all the questions concerning an individual problem were asked, the alternative solutions were evaluated, and the most acceptable alternatives were defined and documented as recommendations. These recommended solutions to identified design-related or maintenance-related problems were then considered during the definition of the maintenance strategy. A further series of implementation recommendations was then formulated to accomplish the objectives of the maintenance strategy selected for the engineered operating cycle (EOC). Where appropriate, additional recommendations were developed for improving system reliability, availability, and maintainability; system preventive maintenance; logistics support; and IMA or depot capabilities.

2.4 DEFINITION OF MAINTENANCE PROGRAM

The recommended maintenance program stems directly from the subsystem and equipment maintenance strategies identified by the analysis. The total maintenance program includes scheduled and unscheduled preventive maintenance, as well as engineered and qualified corrective maintenance required to maintain the system at an acceptable level of material condition and availability over an extended operating cycle.

Engineered corrective maintenance comprises tasks that are well defined and must be accomplished periodically. Once these engineered tasks were identified, the frequency of accomplishment, the manpower resources required for accomplishment, and the maintenance level required to perform the work were determined.

Qualified maintenance tasks -- nonspecific repairs that are likely to be required but cannot be characterized precisely as to nature or frequency -- were also identified, on the basis of historical data, so that blocks of man-hours could be reserved at specified intervals for the completion of probable but nonspecific class C repairs on the subsystems or equipments being analyzed. The engineered and qualified tasks were then incorporated in the DD-963 Class maintenance plan (CMP).

CHAPTER THREE

RESULTS

3.1 OVERVIEW

This chapter presents the results of the SMEA of the DD-963 Class 400 Hz power conversion and distribution systems included in SWAB groups 314-4, static power supplies; 324-1, switchboards: and 324-4, protective devices. The major 400 Hz equipments from SWAB groups 314-4, 324-1, and 324-4 are listed in Appendix A.

The DD-963 Class 400 Hz power conversion and distribution system consists of three CV-3230/S solid-state static frequency converters (SSFCs), two 400 Hz switchboards, and two voltage and frequency monitoring equipments. The MDS data submitted by the DD-963 Class ships on these equipments are summarized, by SWAB group, in Table 3-1. As indicated therein, SWAB group 314-4, specifically the CV-3230/S SSFCs, accounted for more than 90 percent of the reported JCNs, man-hours, and parts costs for the 400 Hz power conversion and distribution system, and was therefore subjected to further analysis. Individually, SWAB groups 324-1 and 324-4 accounted for insignificant portions of the system maintenance burden. Review of CASREP, MDS, and other pertinent data for these SWABs identified no class problems or repetitive maintenance actions. Hence, SWAB groups 324-1 and 324-4 are not discussed further in this report.

Subsequent sections of this chapter describe the functional relationship of the CV-3230/S SSFC to the ships' primary and secondary missions. The results of the analysis of the historical maintenance data are presented. Recommendations are also included, when appropriate, for maintenance strategies for this equipment that will reduce or eliminate repetitive maintenance actions and related equipment failures that would have a significant impact on the ships' maintenance burden during an extended operating cycle.

3.2 EQUIPMENT AND SYSTEM DESCRIPTION

The CV-3230/S SSFC, is a 60/400 Hz solid-state, water-cooled, static frequency converter that produces 150 kW of 450 V, 3-phase, 400 Hz output power using ships service 440 V, 3-phase, 60 Hz input power.

There are three CV-3230/S SSFCs installed on each DD-963 Class ship. Two SSFCs, designated 1RS1-A and 1RS1-B, are installed in 400 Hz Converter Room No. 1 (01-188-01-Q) and are serviced by a single 400 Hz switchboard

TABLE [illegible]. MDS DATA SUMMARY OF 60/400 HZ POWER CONVERSION AND DISTRIBUTION SWAB GROUPS 314-4, 324-1, AND 324-4

		JCNs		Man-Hours				Parts Cost	
SWAB Group	Description	Reported	Percentage of Total	Ships' Force	IMA	Total	Percentage of System Total	Dollars	Percentage of Total
314-4	60/400 Hz Static Frequency Converters	797	92.3	9,878	148	10,062	97.7	385,578	97.3
324-1	400 Hz Switchboards	54	6.3	172	31	203	2.0	10,545	2.7
324-4	400 Hz Protective Devices	12	1.4	31	2	33	0.3	13	-
	System Total	863	-	10,081	181	10,298	-	396,136	-

designated 1SF. The third SSFC, designated 2RS1-A, is installed in 400 Hz Converter Room No. 2 (01-240-0-Q) and serviced by 400 Hz switchboard 2SF. Ships service 440 V, 3-phase, 60 Hz power is fed to each SSFC via individual manual bus transfer (MBT) switches installed in their respective spaces.

The 400 Hz switchboards provide operational control and monitoring functions for the SSFCs and serve as the main feed points for the 400 Hz power distribution system. Bus tie circuit breakers are installed in 400 Hz switchboards 1SF and 2SF, and there is a bus tie arrangement between them to allow: (1) SSFCs 1RS1-A or -B to furnish power to 400 Hz switchboard 2SF, (2) SSFC 2RS1-A to furnish power to 400 Hz switchboard 1SF, or (3) two or more of the SSFCs to be connected in parallel for increased load requirements.

The three CV-3230/S 60/400 Hz SSFCs and associated power distribution system provide 400 Hz power to the ship's tactical data system, fire control system, interior and exterior communications systems, and helicopter support equipment, and therefore play a critical role in support of the DD-963 Class ship's primary mission areas.

3.3 CORRECTIVE MAINTENANCE SUMMARY

The MDS data submitted on the CV-3230/S SSFCs by the 15 DD-963 Class ships analyzed are summarized in Table 3-1 and presented in detail in Appendix B.

Review of the MDS data reported against the CV-3230/S SSFCs, indicates that the 15 DD-963 Class ships documented a total of 797 maintenance actions accounting for a total of 10,062 maintenance man-hours at a parts cost of $385,578. This equates to an average of 296.8 man-hours and a parts cost of $11,374 per ship operating year. The MDS data file contained complete job information, including maintenance man-hours, parts requirements and costs, and applicable narrative and coded information, on 65 percent (514) of the maintenance actions. Only parts requirements and costs were reported on the remaining 35 percent (283 maintenance actions).

Analysis of the 514 maintenance actions for which complete MDS data were available indicates that an average of 20 maintenance man-hours was required per maintenance action. Ship's force documented the majority of the maintenance man-hours (9,878) on the CV-3230/S SSFCs during the data period. Ship's force man-hour distribution figures for the 514 maintenance actions show that 57 percent (295 maintenance actions) required less than 8 man-hours, 32 percent (164 maintenance actions) required between 8 and 50 man-hours, and 11 percent (55 maintenance actions) required more than 50 man-hours.

Only nine of the 514 maintenance actions reported IMA man-hours. A total of 184 IMA man-hours were documented, for an average of 20 hours per maintenance action. The man-hour distribution figures for these nine JCNs indicate that two actions documented zero man-hours, four documented between 1 and 5 hours, and one documented between 11 and 15 hours, and two documented more than 50 hours.

The documented "cause" codes indicate that the major causes of CV-3230/S SSFC malfunctions were "normal wear and tear" (31 percent), "manufacturer/installation defects" (26 percent), and "inadequate design" (23 percent). According to the "when discovered" codes, most of these malfunctions were discovered during "normal operation" (37 percent) and "inspection" (37 percent).

Deferred action was documented on 61 percent of the maintenance actions reporting ship's force man-hours. Documented "deferral reason" codes identify the major reasons for deferred maintenance as "lack of material" (33 percent), "other/not applicable" (24 percent), "lack of facilities/capabilities" (23 percent), and "not authorized for ship's force accomplishment" (13 percent).

Analysis of the documented "type availability" codes indicates that ship's force personnel considered themselves capable of accomplishing 29 percent of the deferred maintenance actions, with "Depot" (38 percent), "IMA" (13 percent), "other" (12 percent), and "Technical Support Unit" (7 percent) maintenance requested for the remaining 71 percent of the deferred maintenance actions.

The "action taken" codes indicate that 45 percent of the deferred maintenance actions remained outstanding at the end of the data period. Further analysis of the "action taken" codes for ship's force-completed maintenance actions, both deferred and nondeferred, reveals that 82 percent required parts, 13 percent required no parts, 4 percent were completed by using "other" means, and 0.8 percent were canceled.

Analysis of the MDS corrective maintenance data on the CV-3230/S SSFCs installed in the DD-963 Class ships indicates that the SSFCs are a major contributor to the ships' maintenance burden, ranking second among the 60 systems on which preliminary analysis was performed.

3.4 FAILURE MODES AND REPETITIVE REPAIRS

The MDS, CASREP, and parts usage data were analyzed; MEA, design review reports, and class action items were reviewed; ship visits were accomplished; and discussions were held with U.S. Navy and contractor technical personnel to identify predominant failure modes, repetitive repair requirements, and specific maintenance actions that require periodic outside assistance.

3.4.1 Design Review Reports

Analysis of the MDS data indicated that major problems in the SSFCs were directly associated with the equipment cooling system and the half bridge assemblies, and review of the historical records available for the DD-963 Classes SSFCs revealed that the problems in these two areas were discovered early in the equipments' history. Records also indicate that certain improvements were made to the SSFCs in the form of ECPs, as a result of a design review in February 1975 and a critical design review (CDR) in January 1977.

The 1975 design review identified problems with leaky and shorted output capacitors, shorted clipper capacitors, high failure rate of output transformers, water leakage at hose connections, and frequency drift of the equipment. Records indicate that ECPs to correct these problems were installed in in-service equipments and production equipments starting with ship set No. 5 (March 1975). Although these ECPs were installed, analysis of the MDS data on the SSFCs commencing with the first entries by the USS SPRUANCE (DD-963) shortly after its commissioning in September 1975 indicated that problems similar to those identified by the 1975 design review continued to affect the DD-963 Class ships' adversely after the ECPs were installed, with the exception of the frequency drift problem.

The 1977 CDR addressed these problems and others identified by INSURV reports and MDS data. The problem areas not previously addressed by the 1975 design review were heat exchanger core failure, electrolysis corrosion in the equipment cooling system, and fuse blowing during parallel operation. In addressing these problems, the 1977 CDR recommended elimination of the salt water cooling loop; incorporation of MARK IV SSFC (updated version of CV-3230/S SSFC aboard FFG-7 Class) product improvements by installation of ECPs regarding heat transfer assembly change, improved deionizer water piping system, and improved deionized water input/output transformer; and incorporation of logic changes to prevent fuse blowing during parallel operation of the SSFCs. As a result of these recommendations, ECPs 62 through 65 were installed in the DD-963 Class SSFCs, and NAVSEA tasked the David W. Taylor Naval Ship Research and Development Center (DTNSRDC), Annapolis, to perform periodic (six-month) inspections of the SSFCs to determine the effectiveness of the ECPs in solving the equipment cooling system problems. A summary of the CV-3230/S SSFC ECPs is presented in Appendix C.

3.4.2 MDS

The MDS data and associated narratives submitted by the 15 DD-963 Class ships were reviewed and analyzed to determine the predominant equipment failure modes and repetitive repair requirements. The following subsections present the results of this analysis by functional categories.

3.4.2.1 Cooling System

The review of the MDS data and associated narratives shows the equipment cooling system to be the predominant cause of equipment failures. Leaks in the cooling system are a major maintenance problem; however, these appear to be minor when compared with the component failures caused by the cooling system. For the most part these components are within the equipments' half-bridge assemblies or the input and output transformers. As indicated in Table 3-2, review of the parts usage data for these and other selected components during the pre- and post-ECP (62 through 65) installation periods reveals an upward trend in usage on the input transformer and output capacitors. Analysis of the available data revealed no explanation of the decrease in usage of the input transformer; however, the decrease in output capacitor usage was attributed to the installation of the improved capacitor mounting brackets that made allowance for the expansion and contraction of the capacitors.

Table 3-2. DD-963 CLASS 60/400 HZ SOLID-STATE STATIC FREQUENCY CONVERTER SELECTED PARTS USAGE DATA

NSN	Description	Quantity Used Pre-ECP		Quantity Used Post-ECP		Total Used in Data Period	
		Total	Per EOY (46.2)	Total	Per EOY ([illegible])	Total	Per EOY (101.7)
9N59[illegible]-01-012-4831	Transformer, Commutation	4	[illegible]	12	0.22	16	0.2[illegible]
9N59[illegible]-01-012-4833	Transformer, Output	11	0.24	21	0.38	32	0.31
9N59[illegible]-01-012-4834	Transformer, Input	11	0.24	[illegible]	[illegible]	16	0.16
9N[illegible]-01-012-62[illegible]2	Fuse, 3[illegible]A	644	13.94	1,013	18.25	1,657	16.29
9N5910-01-013-2360	Capacitor, Output	26	0.56	[illegible]	[illegible]	31	0.30
9G613[illegible]-304-341[illegible]	SCP	34	0.74	62	1.12	96	0.94
9G613-[illegible]-304-3421	SCP	31	0.67	79	1.42	110	1.08
1H[illegible]-306-833[illegible]	Fuse, 125A	182	3.94	269	4.85	451	4.43

The external mounting of the heat exchanger and conversion from salt water to ship's chilled water as a source of cooling for the equipment pure water cooling loop appear to have made some improvements in cooling system performance. The problem of ruptured salt and pure water heat exchanger and resulting contamination of the pure water cooling loop does not appear in the post-ECP (62 through 65) MDS data. However, the detrimental effects of cooling system corrosion continue to be a major problem. The corrosion caused by the dissimilar metals in the pure water cooling loop decreases the efficiency of the cooling system and results in failure of the components directly serviced by the cooling loop. The problems associated with the cooling system can be expected to continue until the aluminum components within the pure water cooling loop are replaced with copper, as confirmed by the inspections of the DD-963 SSFC cooling systems carried out by DTNSRDC as a result of the 1977 CDR generated task.

The first DTNSRDC inspection was conducted in August 1978 aboard the USS PAUL F. FOSTER (DD-964) after the ship experienced failure of two of its SSFCs as a result of cooling system corrosion. Subsequent inspections were performed on the USS STUMP (DD-978) and USS ARTHUR W. RADFORD (DD-968) in December 1978; USS BRISCOE (DD-977), USS ELLIOT (DD-967), USS DAVID R. RAY (DD-971), and USS O'BRIEN (DD-975) in January 1979; and USS HEWITT (DD-966), USS KINKAID (DD-965), and USS MERRILL (DD-976) in May 1979. Review of the MDS data and the DTNSRDC reports on the inspection of the SSFCs aboard these ships indicates that a corrosion problem still exists in the modified 60/400 Hz static frequency converters for DD-963 Class ships.

Discussions with Mr. E. B. Bieberich of DTNSRDC, who participated in the 1977 CDR and performed the previously noted inspections, indicated that the recommendations made by the CDR board were an attempt to make the SSFC as operationally sound as possible and that the recommended fixes did not correct the basic problem: "marginal design from a total systems standpoint."* Mr. Bieberich indicated that two basic problems remain: (1) the modified unit's cooling system still contains dissimilar metals -- aluminum, brass, copper, and stainless steel -- which results in system corrosion; and (2) the equipment demineralizer system does not meet the minimum standards (MIL-STD-1399). He reiterated the statement made in his report on the inspection of the USS PAUL F. FOSTER (DD-964) SSFCs, that the corrosion problem with the DD-963 Class ships' SSFCs will continue to exist until "comprehensive corrective action is taken." That corrective action includes replacement of all aluminum cooling system components with copper and upgrading of the demineralizer unit to meet MIL-STD-1399 by installing a BARNSTED unit for water deionization and filtering.

Review of the DD-963 Class Retrofit Status Report, dated October 1979 reveals that there are two retrofit items, Number 342-60/400 Hz Converter Phase I changes and Number 350-60/400 Hz Converter Phase II changes, that, when combined, will accomplish the required comprehensive improvements. The Phase I changes replace existing conductivity probes with platinum probes, install a specific conductivity meter, provide a remote conductivity

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*Investigation of Corrosion Failures in the Cooling System of 60/400 Hz Static Frequency Converters for DD-963 Class Ships by E. B. Bieberich, DTNSRDC/TM-28-78/315.

alarm, install a thermostatic switch in the input and output pure water manifolds, update the Control Logic P/C assembly, and remove some obsolete components on the Circuit Breaker Trip Control P/C. Phase II changes replace the pure water deionizer with a BARNSTEAD system, replace the pure water strainer with a submicron filter, replace the aluminum cooling components with copper, replace the accumulator with an externally mounted stainless steel unit with increased capacity, replace several rubber hoses with stainless steel tubing, and install a conductivity probe in the lower part of the cooling system. Discussion with PMS-389 indicated that the Phase I changes have been accomplished on DD-974 through DD-985. Phase I changes are to be accomplished on DD-963 through DD-973 as scheduled by the Type Commander and on DD-980 through DD-990 during PSA.

The Shipalt Status Report for the DD-963 Class, dated September 1979, indicates that a shipalt proposal was approved by PERA (CRUDES) in May 1979 for complete replacement of the SSFCs aboard the DD-963 Class ships (Shipalt DD-963-0247K 400 Hz Converter Replacement). Discussions with cognizant Navy technical personnel revealed that the new SSFC, a 100 kW, air-cooled 60/400 Hz SSFC, which is slated as the replacement SSFC under the proposed shipalt is currently in its final testing at Teledyne Inet. Indications are that the first units will be ready for installation aboard a DD-963 Class ship in late 1980.

The proposed shipalt, DD-963-0247K 400 Hz Converter Replacement, and the Phase I and II 60/400 Hz Converter changes, retrofit items 342 and 350, present two alternatives to ensure that the DD-963 Class ships are provided with a reliable 400 Hz power source. Assuming that the testing of the 100 kW, air-cooled SSFCs is completed with satisfactory results, the replacement of the water-cooled SSFCs under shipalt DD-963-0247K appears to be the best long-term means of providing the DD-963 Class ships with reliable 400 Hz power. It is recommended that this alternative be fully pursued. As an interim measure, until the air-cooled replacement SSFCs have completed operational testing satisfactorily and enough units have been produced to fulfill the DD-963 classes requirements, it is recommended that the 60/400 Hz Converter Phase I be completed on DD-963 through DD-973 and Phase II changes be accomplished on all DD-963 Class ships during each ship's next SRA. In addition, it is recommended the Phase I and II changes be accomplished on DD-980 through DD-990 during each respective ship's PSA.

Pending completion of Shipalt DD-963-0247K, and in addition to the interim Phase I and II changes, it is recommended that the CMP contain an engineered task for the accomplishment of a class B overhaul on the CV-3230/S SSFCs. The Class B overhaul should include overhaul or exchange of the half-bridge assemblies and other components serviced by the cooling system, overhaul or exchange of the cooling system circulating pump, replacement of all cooling systems hoses, and performance of electrical repairs as required.

3.4.2.2 Electrical

Analyses of the MDS data and associated narratives indicate that repetitive problems were experienced by the DD-963 Class ships in the parallel operation of the SSFCs, in addition to the failures of the Control Logic (A107A6) and other P/C cards.

Problems regarding the parallel operation of the SSFCs were among those addressed by the 1977 CDR, and as a result of the CDR's recommendations, ECP 62 was installed to "eliminate fuse blowing due to loss of input power during parallel operation." Review of post-ECP 62 MDS data, and discussions with DD-963 Class ships' electrical officers and technicians indicate that problems with the parallel operation of the SSFCs still exist. The automatic load-sharing circuitry does not appear to function effectively, and when one of the paralleled units trips off the line, it causes all paralleled units to trip off the line. One ship's electrical officer said that the ship has experienced so many problems in operating the SSFCs in parallel that they just did not use them in parallel any more. He found the 150 kW capability of the individual SSFCs fully capable of supplying the ships 400 Hz load and reported that if it approached the 150 kW limit, they would split the load between two units instead of using a parallel configuration. Discussions with technicians on other DD-963 Class ships revealed that using the SSFCs in split load instead of a parallel configuration appears to be a common practice on DD-963 Class ships.

The problem remains partly the control circuitry of the SSFCs and partly the shipboard technicians' poor understanding of the control circuitry, as expressed by the technicians during ship visits. They also expressed a general lack of confidence in the training they had received. The lack of understanding of the operation of the SSFC control circuitry and the SSFC in general was confirmed in discussions with Teledyne Inet technical representatives, and it is evident in the MDS and CASREP data, which show the dependence of the ships on Teledyne Inet technical representatives for maintenance assistance.

Discussions with personnel at the Great Lakes Naval Training Center regarding the 60/400 Hz Power Converter Course (A-652-077) revealed that the SSFCs installed at the school are as they were when originally delivered from the factory. None of the ECPs that have been installed in the DD-963 Class ships SSFCs have been accomplished on the school's equipment. In addition, review of the "Curriculum Outline for 60/400 Hz Power Converter Course" (A-652-0077), dated March 1977, and "Instructors Guide for 60/400 Hz Power Converter Course A-652-077," dated May 1977, as provided by the school, indicates that they make no provision for discussing or giving training in the ECPs.

Additional discussion with personnel at the training center indicated that they were unaware of the problems the DD-963 Class ships were experiencing with the SSFCs, e.g., the inability of the units to operate satisfactorily in parallel. Similarly, discussion with a manufacturer's technical representative aboard one of the DD-963 Class ships visited in conjunction with this analysis revealed that there are numerous trouble-shooting and repair techniques or hints used by the technical representatives that are not known to the shipboard technicians. For example, one problem encountered was a defective commutation transformer. A replacement commutation transformer was not available, and the technical representative instructed the ships technicians to make sure that they replaced the selinium controlled rectifiers (SCRs) when the commutation transformer was replaced. He explained that when the commutation transformer failed, it more than likely

weakened the associated SCRs. If the SCRs were not replaced along with the commutation transformer, they would probably fail shortly and could cause the new commutation transformer to fail. The shipboard technicians stated that they were unaware of this interrelationship. They further indicated that they had replaced the defective commutation transformer less than a month before but had not changed the associated SCRs.

On the basis of the information provided in the preceding paragraphs, the following actions are recommended:

- Install all ECPs in the SSFCs at the Great Lakes Naval Training Center, and provide information to training course instructors regarding completed and proposed ECPs for updating course materials.
- Develop and distribute an information bulletin that provides shipboard SSFC technicians with information on troubleshooting, repair, and other maintenance techniques. It is suggested that the bulletin be similar to the Electronics Information Bulletin (EIB) series published by Naval Ship Engineering Center (NAVSEC Code 6181C) for electronics systems and equipments.

Although the MDS data indicate that the corrective maintenance actions on the CV-3230/S SSFCs were predominantly on the cooling system or were associated with attempts to operate the units in parallel, a significant number of maintenance actions involved the various P/C cards used in the SSFCs. The parts usage data for the respective P/C cards are presented in Table 3-3. The logic control card (A107A6) was the card replaced most often (43 times). The MDS data indicate that 24 logic control cards were replaced in 17 separate maintenance actions on 9 separate DD-963 Class ships using NSN 2H-6130-01-060-3808. This is the NSN listed in the APL (112700002C). The MDS data further indicate that 9 logic control cards were replaced in 7 separate maintenance actions aboard six DD-963 Class ships under NSN 1H-6130-00-536-4213, the NSN listed in the MEA (K041A) for the DD-963 SSFCs. In addition, detailed analysis of the MDS narratives revealed that an additional 11 logic control cards were replaced in 11 separate maintenance actions, the replacement P/C cards having been obtained with open purchase requisition or from Teledyne Inet technical representatives under the warranty/guarantee program.

The appearance of two separate NSNs for the logic control card assembly for the CV-3230/S SSFC, with the Navy Management Data List (NMDC), dated January 1980, showing both numbers to be valid, warranted further investigation. Discussions with NAVSSES Philadelphia, Ships Parts Control Center (SPCC), Mechanicsburg, and Teledyne Inet personnel revealed that NSN 1H-6130-00-536-4213 was the stock number for the logic control card assembly in the original CV-3230/S SSFC and NSN 2H-6130-01-060-3808 is the stock number for the logic control card assembly as modified under ECP-62. The discussion further revealed that a third NSN (2H 6130-LL-HD-2E977) will appear for the logic control card assembly as modified by ECP-70.

The DD-963 Class Advisory 1-79 indicated a need to identify and purge from the supply system printed circuit cards that did not have the latest ECP changes installed (see Appendix D). The discussion in the preceding

Table 3-[illegible]. DD-963 CLASS SIGNIFICANT PARTS USAGE ON THE CV-3230/S SOLID-STATE STATIC FREQUENCY CONVERTER

Part Identification		Current Cost Per Unit (Dollars)	Quantity Per Component	Total Part Population	Ship's APL Allowance	Number Replaced	Ratio (X 100) of Parts Replaced to Total Population	Number of JCNs Reported	Number of Ships Reported
NSN	Nomenclature								
Transformers									
9N5950-01-[illegible]-4831	Commutation Transformer	[illegible]1.54	6	270	1	16	5.9	10	6
9N5950-01-012-4833	Output Transformer	[illegible]27.44	3	135	1	32	23.7	29	11
9N5950-01-012-4834	Input Transformer	3481.62	3	135	1	16	11.9	8	5
Capacitors									
9N5910-01-[illegible]	Output Capacitor	34.23	12	540	*	31	5.7	13	6
9N5910-01-013-2361	Capacitor	27.77	21	945	5	11	1.2	6	5
9N5910-01-[illegible]	Capacitor	[illegible].88	12	540	3	44	8.2	12	9
9N5910-01-[illegible]	Capacitor	54.88	1	45	1	14	31.1	7	6
9N5910-[illegible]	Commutation Capacitor	[illegible].28	72	3240	1	176	5.4	21	11
Semiconductor Devices									
[illegible]	Rectifier	16[illegible].92	12	540	3	83	15.4	26	13
[illegible]	[illegible]	[illegible]2.35	12	540	3	96	17.8	29	10
[illegible]	[illegible]	[illegible].47	12	540	2	110	20.4	20	11
1N5961-[illegible]	Diode	[illegible].35	24	1080	4	41	3.8	12	[illegible]
1N5961-[illegible]-1467	Diode, Forward	[illegible].25	3	135	1	19	14.1	12	10
1N5961-[illegible]-1498	Diode, Reverse	[illegible].73	6	270	1	15	5.6	8	8
9N5961-[illegible]	[illegible]	[illegible]	[illegible]	225	1	6	2.7	3	3
Printed Circuit Boards and Assemblies									
1N6130-01-[illegible]-2417	Crystal Control Timing	[illegible]	1	45	1	6	13.3	6	4
1N6130-01-[illegible]	Control Board	[illegible]	1	45	1	23	71.1	17	9
1N6130-[illegible]-421[illegible]	Control Board	[illegible]			[illegible]	[illegible]		7	6
1N6130-01-[illegible]	Current Limit	4.4[illegible]	1	45	1	3	6.7	3	3
1N6130-01-[illegible]-391	[illegible] Monitor	4[illegible]	1	45	[illegible]	5	11.1	5	3
1N6130-[illegible]	Alarm	4[illegible]	1	45	1	14	31.1	12	7
1N6130-[illegible]-414[illegible]	Dual Redundant [illegible]	[illegible]	1	45	1	8	17.8	[illegible]	3
1N6130-[illegible]	Lamp Driver	[illegible]	1	45	1	11	24.4	5	7
1N6130-[illegible]-1977	Pulse Generator	[illegible]	3	135	1	8	5.9	7	6
1N6130-[illegible]	Blown Fuse Detector	4[illegible]	[illegible]	135	1	5	3.7	3	3
1N6130-[illegible]-[illegible]91	Voltage Regulator	[illegible]	1	45	1	10	22.2	8	6
1N6130-[illegible]	Phase Control	[illegible]	3	135	1	3	2.2	3	3
1N6130-[illegible]-116	[illegible] Assembly	[illegible]	3	135	1	[illegible]	5.9	8	7
Other									
[illegible]461[illegible]-01-012-3401	[illegible]	[illegible]	1	45	**	52	377.8	21	7
1N6130-01-[illegible]		[illegible]				36		14	5
[illegible]461-01-4[illegible]-7[illegible]18		[illegible]				[illegible]		16	8
[illegible]-01-012-[illegible]	Fuse [illegible]	[illegible]	6	270	6	[illegible]	[illegible]14.4	118	15
1N5920-[illegible]-833[illegible]	Fuse 125A [illegible]	[illegible]	6	270	15	451	167.0	38	13
[illegible]-01-014-7141	Flow Switch	[illegible]	1	45	*	[illegible]	15.[illegible]	[illegible]	[illegible]
9N5915-01-041-2059	EMI Filter	146.[illegible]	1	45	1	7	15.6	5	5

*Not listed
**Not listed under NSN shown

Data Period - September 1976 through September 1979

paragraph indicates that there is a continuing requirement to identify and purge CV-3230/S SSFC components in the supply system that have not been modified in accordance with the latest ECPs. Therefore, it is recommended that the supply system be searched for CV-3230/S SSFC components that have not had the latest ECP modifications installed and that these components be purged from the supply system.

Analysis of the P/C card failures did not reveal any pattern or trend. The failures appeared to occur randomly and, for the most part, could not be associated with failures of other sections of the equipment. There were two MDS entries on two separate ships indicating that the Quasi-Generator P/C card (A107A9) failed as a result of failures of other circuit components; however, sufficient information was not provided for further analysis.

The MDS data also contained entries documenting periodic replacement of various electrical cables as a result of worn and cracked insulation and general cable wear caused by the removal and replacement of the half-bridge assemblies. The Q-1R PMS task (MIP EL-5/188) contains a step to "inspect" wiring for overheating, chafing, frayed, or chipped insulation that reminds ship's force technicians of the maintenance requirements on the wiring throughout the SSFC during the operating cycle. To assist ship's force in this task and ensure that the wiring is in prime condition at the beginning of each ship's operational cycle, it is recommended that the Class B overhaul recommended in the previous section include replacement of the equipment wiring associated with the half-bridge assemblies.

3.4.2.3 Other

Analysis of the MDS data and associated narratives revealed the presence of numerous INSURV discrepancies that remained outstanding at the end of the data period. A summary of these discrepancies is presented in Appendix E. Although each of these discrepancies affects the reliability and maintainability of the DD-963 Class SSFCs, there are two that were mentioned by the shipboard technicians during ship visits as being particular problems:

(1) "There is no means for shipboard technicians to identify the ECPs that have been accomplished on the SSFCs aboard." In addition, the shipboard technicians pointed out that the technical manual for the equipment is not current in that it lacks changes to reflect installed ECPs. The lack of a means to identify completed ECPs and the lack of current technical documentation both degrade the shipboard technician's ability to maintain the equipment effectively. Class Advisory 1-79 indicated that an updated technical manual was to be issued; however, ships have not received the update and are still using the technical manual (NAVSEA 0962-LP-077-4010) dated 15 May 1978. Accordingly, it is recommended that a means of identifying completed ECPs, similar to the field change identification plates for electronic equipment, be instituted, and that the technical manual be updated to reflect current ECP status.

(2) "There are no provisions in the equipment or converter spaces to assist in the removal of half-bridge assemblies and other heavy

components." The MEA (K041A) indicates that removal of the half-bridge assemblies is required for maintenance; however, no provisions were made in the equipment or equipment spaces (01-188-01-Q and 01-240-0-Q) to aid shipboard technicians in the removal of these or other heavy components. Therefore, it is recommended that some provision be made in 400 Hz Converter Room No. 1 (01-188-01-Q) and 400 Hz Converter Room No. 2 (01-240-0-Q), such as a pad eye and chain hoist with an appropriate sling or platform, to aid shipboard technicians in the removal and replacement of half-bridge assemblies and other heavy components.

3.4.3 CASREPs

Analyses of the CASREP data submitted by the 15 DD-963 Class ships included in the survey indicates that there were a total of 92 CASREPs submitted on the CV-3230/S SSFCs for a total downtime of 93,818 hours. The downtime included 63,988 hours (68 percent) awaiting parts, and 29,830 hours (32 percent) performing corrective maintenance. Eight of the CASREPs remained outstanding at the end of the data period.

The total downtime of 93,818 hours does not include the figures for the eight CASREPs that remained outstanding, and it indicates an average downtime of 2,455.9 hours per ship operating year (38.2 EOY), or 102 days for the class.

Approximately 83 percent (76/92) of the CASREPs involved the cooling system. Nineteen of the CASREPs (21 percent) were submitted as a direct result of a cooling system failure. The other 57 CASREPs (62 percent) involved failures of components serviced by the cooling system, and they are attributed to this system. Table 3-4 presents a summary of the CASREP parts usage data for parts required in more than one CASREP. The five items involved in the greatest number of CASREPs are components affected by the cooling system, a trend that is consistent with the overall parts usage and MDS data for the DD-963 Class SSFCs. The cooling system and affected components can be expected to remain the predominant factor contributing to equipment CASREPs, as well as the corrective maintenance burden for the SSFCs, until the cooling system is purged of all dissimilar metals and the deionized water filtration and deoxygenization system is upgraded to meet MIL-STD-1399 or the units are replaced with the new air-cooled units as proposed under Shipalt DD-963-0247K.

Eight of the 13 P/C assemblies of the equipment control console assembly (A107) were involved in one or more CASREPs. Specific causes for the P/C assembly failures could not be determined from the CASREP data. However, discussions with shipboard technicians and Navy and contractor personnel did indicate that some of the P/C assembly failures were a result of equipment cooling system failures. They also indicated that other P/Cs had not actually failed but were reported as failures as a result of lack of understanding and experience of shipboard technicians. The failures of P/C assemblies caused as a result of cooling system failures can be expected to decrease with the installation of cooling system improvements described above. The

Table 3-4. DD-963 CLASS CASREP PARTS USAGE DATA FOR CV-3230/S SOLID-STATE STATIC FREQUENCY CONVERTER

Nomenclature	NSN	Number of CASREPs	Number Replaced
Output Transformer	5950-01-012-4833	18	28
600 Amp, 1000 V 15 Vsec SCR	6130-00-391-3419	10	33
Input Transformer	5950-01-012-4834	10	15
Control Logic P/C	6130-00-536-4213	10	14
Commutation Transformer	5950-01-012-4831	9	12
Output Capacitor	5910-00-454-3980	8	94
750 Amp, 1000 V SCR	6130-00-391-3421	8	51
Control Logic P/C	6130-00-060-3808	6	9
Crystal Control Timing P/C	6130-00-039-2417	6	8
Fuse 300 Amp	5920-01-012-6202	5	86
SCR P/C	6130-00-538-2116	5	13
Forward Diode	5961-00-689-1497	4	20
Filter	4610-01-012-3461	4	11
Rectifier	6130-00-391-8721	4	9
Quasi Generator P/C	6130-00-538-1977	4	6
Fuse 125 Amp	5920-00-396-8339	3	38
Reverse Diode	5961-00-689-1498	3	9
Capacitor	5910-01-042-7569	3	7
Hose	4720-01-012-5665	2	180 ft.
EMI, Filter	5915-01-041-2959	2	15
Diode Fast Recovery	6130-00-391-8721	2	11
50 uf, 600 V Capacitor	5910-01-013-2360	2	8
0.22ohm, 17watt Resistor	5905-00-931-3708	2	6
50 uf, 600 V Capacitor	5910-01-013-2361	2	5
Inverter Driver Transformer	5950-01-012-4829	2	4
Blown Fuse Detector P/C	6130-00-538-1989	2	3
Diode	5961-00-558-8588	2	3
Lamp Latch P/C	6130-00-538-1959	2	2
Voltage Regulator Rectifier P/C	6130-00-538-1991	2	2

Data Period - September 1975 through November 1979

problem of lack of shipboard technician experience is expected to be resolved with time, but the resolution could be accelerated with an improved training program, as discussed in Section 3.4.2.2.

3.4.4 Parts

The significant parts usage data for the CV-3230/S SSFCs are summarized in Table 3-4. These data represent parts used in corrective maintenance actions on the CV-3230/S SSFCs that were requisitioned and received by using the appropriate NSN. It does not reflect parts that were replaced by the manufacturer under the warranty/guarantee program or parts requisitioned and received via open purchase requisitions. For example, although the reported parts usage for the output transformer from MDS is 23.7, a more detailed analysis shows it to be 33.3. CASREP reports also support the higher number since they show that in 18 CASREPs, 28 output transformers were used. Analysis of the MDS narratives and CASREP data also indicates that the replacement ratios for the input transformer, commutation transformers, and output capacitors are higher than those reflected in the MDS parts usage data.

The data in Table 3-3 have been divided into five categories for presentation purposes: transformers; capacitors: semiconductor devices: printed circuit card assemblies; and other.

3.4.4.1 Transformers

The transformer parts usage data indicates that the output, input, and commutation transformers have replacement rations of 23.7, 11.9, and 5.9, respectively. As indicated in the preceding section, these figures reflect only those transformers recorded in the MDS parts usage data. Review of the MDS data narratives and discussions with shipboard technicians and other Navy and contractor technical personnel revealed that there have been numerous replacements of these transformers that are not reflected in the MDS data.

The MDS narratives and discussions with cognizant Navy technical personnel indicated that most of the transformer failures can be directly related to the problems with the equipment cooling system. Failures can be attributed to decreased cooling system efficiency as a result of system corrosion (Section 3.4.2.1) and shutdown of the cooling system as a result of momentary loss of ships service 60 Hz power.

The failures of tranformers caused by cooling system shutdown as a result of momentary loss of ships service 60 Hz power were cited by one of the shipboard technicians. He pointed out that the control circuitry of the SSFCs including the way in which the SSFCs are connected to ships service 60 Hz power, requires the SSFC to be manually restarted after interruptions in ships service 60 Hz power. He indicated that the spaces in which the SSFCs are installed are normally unmanned, and the manual restart requires that a qualified technician be located, proceed to the appropriate space, perform a visual inspection of the equipment, and complete manual restart procedure. He estimated that this process takes a minimum of 5 to 7 minutes,

during which the SSFC is totally deenergized, including the cooling system. In this state, the equipment is provided no means of dissipating the heat that has built up and "the equipment just sits and bakes or steams in its own heat." Further, during this time delay the ship is without 400 Hz power for the various systems that rely on it for a primary power source.

Review of the equipment technical manual for 60 Hz power distribution shows that the 60 Hz power is fed through the maintenance switch. When this switch is in the operate position, 60 Hz 440 Vac is available at the input terminals E101, 102, and 103) and applied to the elapsed time meter, control logic circuits, 400 Hz generating circuits, and cooling water circulating pump. Should the SSFC be shut down manually, or automatically as a result of a fault or blown fuse or momentary loss of ships service 60 Hz power, power is removed from the entire equipment. This includes power for operation of the cooling water circulating pump. Components such as the input, output, and commutation transformers are "steamed and pressure cooked," while the output capacitors and SCRs simply bake. To ensure a continuous flow of cooling water, when 60 Hz power is available, it is recommended that the cooling water circulating pump be connected to ships service 60 Hz power independently of the SSFC manual reset circuitry. Further, it is recommended that an automatic bus transfer (ABT) switch be used instead of the manual bus transfer (MBT) switch that furnishes power to the SSFCs under the current ship configuration.

The fact that all three SSFCs aboard the DD-963 Class ships are connected to ships service 60 Hz power via MBTs was also indicated by the same technician. Providing power to the SSFCs via MBTs instead of ABTs could be a significant factor in several of the electrical problems being experienced with the SSFCs. The unexplained blowing of input/output fuses may result from the momentary loss of input power and accompanying surge, such that manual reset circuitry did not unlatch. It is recommended that further study be undertaken regarding the provision of ships service 60 Hz power to the SSFCs via ABTs instead of MBTs and the resulting effects on equipment reliability, as well as the ensuring of a continuous source of 400 Hz power to the various combat and other systems that require 400 Hz as a primary power source.

The failure rate of the transformers and other components directly serviced by the equipment cooling loop can be expected to increase during the operating cycle as a result of the cumulative effects of cooling system corrosion and inadvertant cooling system shutdown. The failure rate will not be reduced until the dissimilar metals are removed from the cooling loop and the deionization and filtration system is improved as set forth in class action items 342 and 350, or the CV-3230/S SSFCs are replaced with the new air cooled units as proposed under Shipalt DD-963-0247K. (See recommendations set forth in Section 3.4.1)

3.4.4.2 Capacitors and Semiconductor Devices

The five capacitors listed in Table 3-4 are in the output and commutation circuitry of the CV-3230/S SSFC. All but one of the capacitors and all the semiconductors listed were required in multiple CASREPs (see Table 3-3). Further, the number of capacitors and semiconductors required per maintenance action exceed the allowable shipboard allowance for all but one of the listed

capacitors (NSN 9N-5910-01-013-2360). Failure of the listed APL shipboard allowance to meet the repair requirements of the equipment applies to most of the components listed on Table 3-4 and confirms discussions held with shipboard technicians and other cognizant personnel that indicated a lack of spare parts provisioning and supply support for the SSFCs. Therefore, it is recommended that a complete review of the spare parts provisioning be accomplished and that shipboard allowance list and provisioning be adjusted in accordance with the findings of the review.

3.4.4.3 Printed Circuit Card Assemblies

Each of the printed circuit card assemblies used in the control console assembly (A107) of the CV-3230/S SSFC is listed in Table 3-4. As indicated therein, the replacement ratios range from 2.2 for the phase control assembly (23C511) to 51.1 for the post-ECP-34 control logic assembly (23C502-1). The specific causes of the failures of the listed P/C assemblies could not be determined from the available data. As previously noted, the Mk IV SSFC aboard the FFG-7 Class is similar to the CV-3230/S but includes numerous improvements in the basic design. It is recommended that those P/C assemblies with a replacement ratio greater than 20 be compared with the replacement ratios and failures of their counterparts in the Mk IV SSFC and that appropriate modification be made to improve their reliability. It should be noted that the control logic P/C assembly is scheduled for replacement with an updated version under ECP-70 (see Section 3.4.2.2).

3.4.4.4 Other

As indicated in Table 3-4, there are five other parts for which parts usage was considered significant.

The deionization cartridge for the equipment cooling system was ordered under three separate NSNs, only one of which, 9C4610-01-012-3461, is listed in DD-963 Class Advisory 38-77 as authorized for use (see Appendix F). The advisory lists five different cartridges and indicates that three of them are interchangeable -- items A, B, and C. The advisory authorized the mixed bed cartridge, NSN 9C4610-00-460-7015, for use in the cooling system of the SSFCs as an interim measure pending completion of an investigation of the use of a combined bed cartridge with deionizer and oxygen scavenger quantities. However, the MDS and parts usage data do not indicate that it was used.

Discussions with Mr. Bieberich at the DTNSRDC, Annapolis, Maryland, indicated that manufacturers had been reluctant to release data on the various cartridges, with the result that a "best cartridge" was not identified. Until such time as the deionizer units currently installed in the CV-3230/S, SSFCs are replaced with the BARNSTEAD unit, under SSFC Phase II changes (see Section 3.4.1) or the CV-3230/S, SSFCs are replaced with the air-cooled units under the proposed Shipalt DD-963-0247K, it is recommended that DTNSRDC continue its efforts to find a best cartridge.

The high usage rate of the fuses is a result of the problem of fuse blowing during parallel operation (see Section 3.4.1) and the procedures

used in troubleshooting the SSFCs. Discussions with Naval and contractor technical personnel indicated that they considered the fuse usage rates within limits.

3.5 PMS SUMMARY

The DD-963 Class PMS Program List of Effective Pages (LOEP) and the MEA (K041A) for the SSFC indicate that MIP EL-5/188 contains the preventive maintenance requirements for the "Power Converter 60/400 Hz." Discussions with personnel at Naval Ship Systems Engineering Station (NAVSSES) Philadelphia revealed that there are three other MIPs that set forth preventive maintenance requirements for the power converters, 60/400 Hz: EL-5/197, EL-5/210, and EL-5/211. MIP EL-5/211 indicates that it is for "Level 4 - Equipment Test," Level 4 equipment being the updated version of the SSFC, currently being installed in the FFG-7 Class ships.

Comparison of the PMS requirements listed on the four separate MIPs showed that the PMS tasks are all similar; however, there are some differences in the priodicity for accomplishment. The PMS requirements on all four MIPs pertain only to the cooling system of the equipment and make no provisions for PMS on the electrical or electronic portions of the equipment. In addition, the PMS requirements for the cooling system do not meet the requirements for electronic equipment cooling systems as set forth on the MIP for Electronic Cooling Systems (A-160/25) or those outlined in the CV-3230/S technical manual (NS 0962-077-4010).

The need for the SSFC PMS Program to meet the requirements as listed on MIP A-160/25 and in the equipment technical manual is documented in the various DTNSRDC reports on inspections of the SSFC cooling system (see Section 3.4.1). In addition, the unreliable operation of the SSFCs aboard the DD-963 Class ships indicates that additional PMS is required to ensure that a reliable source of 400 Hz power is available.

To assure that general PMS requirements for the cooling system and electrical and electronic portions of the CV-3230/S SSFCs are met, it is recommended that the PMS requirements listed in Table 3-5 be added to MIP EL-5/188. Inclusion of these requirements in the PMS program for the CV-3230/S SSFCs and accomplishment of the recommended hardware changes to the equipment set forth in other sections of this report will greatly improve the reliability of the CV-3230/S SSFCs.

3.6 MAINTENANCE STRATEGY

The maintenance plan for the CV-3230/S SSFC set forth in MEA K041A states: "Organizational level repairs will be replace or throw-away to the piece part level of all nonrepairable items. The half-bridge assembly will have to be removed to gain access to all components not accessable from the front panel. Preventive maintenance will be in accordance with (MIP) EL-5/ 188-72. A repair action for overhaul of the cooling system is included as

Table 3-5. RECOMMENDED ADDITIONS TO THE PMS PROGRAM (MIP EL-5/188) FOR THE CV-3230/S, SSFCs ABOARD DD-963 CLASS SHIPS

	PMS Requirement	Reference(s)
(W-1)	Clean and inspect cooling system pure water strainer	MIP A-160(W-2) MRC 15 2LLTN Class Advisory 1-79
(M-1R)	Check and adjust if required, the voltage and phase balance Note: Accomplish monthly and upon replacement of one or more of the Quasi generator P/C assemblies	Technical Manual paragraph 6-5
(Q-1)	Test operation of thermoswitch and mixing valve assembly	MIP A-160(Q-1) MRC T47 3NFN N
(Q-2)	Test operation of system flow switch	MIP A-160(Q-3) MRC T36 3CJU N
(S-1R)	Clean conductivity sensors; Test conductivity meter; and Test conductivity sensors. Note: Accomplish semiannually and when malfunction is suspected	MIP A-160(S-1R) MRC T47 3NFC N Technical Manual paragraph 4-17
(S-2)	Test parallel operation of converters (Test procedures to be developed)	New requirement based on this analysis
(A-1)	Clean and inspect fresh and distilled water heat exchanger	MIP A-160(A-2) MRC 77 3RSA N
(C-1)	Submit work request to repair activity to chemically clean, hydrostatically test and repair, as required, the pure water cooling loop and fresh and distilled water heat exchanger	MIP A-160(C-1)

an OH (overhaul) task and will be performed as an overhaul function during the ship overhaul period. A single repair action for the pump/motor is documented, and upon failure the entire unit will be inspected and parts renewed as required to increase reliability and reduce downtime."

The current maintenance philosophy for the CV-3230/S SSFC is performance of PMS, run-to-failure, and performance of corrective maintenance and overhauls as required. On the basis of this analysis, it is recommended

that an engineered task be included in the DD-963 Class CMP to accomplish a depot-level Class B overhaul on the CV-3230/S SSFCs during ROH. The requirement for this task should be reevaluated upon completion of the Static Converter Phase I and II changes or Shipalt DD-963-0247K.

Review of the Ship Alteration and Repair Package (SARP) for the USS SPRUANCE (DD-963), dated 4 March 1980, indicates that Class B overhauls are scheduled for the ship's three 60/400 Hz converters.

The results of this analysis indicate that the CV-3230/S 60/400 Hz solid-state static frequency converters installed in the DD-963 Class ships will not perform satisfactorily during the operating cycle unless comprehensive improvements are made to the equipment, such as the Phase I and II changes listed in retrofit items 342 and 350, or the units are replaced with more reliable units as proposed in Shipalt DD-963-0247K. In addition to the update or replacement of the CV-3230/S SSFCs it is necessary to make certain changes to the PMS Program for the equipment and to supply support so that satisfactory operation will be assured throughout the operating cycle.

CHAPTER FOUR

CONCLUSIONS AND RECOMMENDATIONS

This chapter summarizes the conclusions and recommendations resulting from the system maintenance engineering analysis for the DD-963 Class 60/400 Hz static conversion equipment, SWAB group 314-4.

4.1 CONCLUSIONS

The following conclusions resulted from this system maintenance engineering analysis:

- The CV-3230/S 60/400 Hz Solid-State Static Frequency Converters (SSFCs) in the DD-963 Class ships are not expected to perform satisfactorily during the operating cycle unless comprehensive improvements are made to the cooling system and control circuitry for parallel operation of the converters.
- The current training course for the DD-963 Class 60/400 Hz Power Converters (A-652-[illegible]77) is inadequate and requires updating to include current equipment configuration as a result of multiple engineering changes on the equipment.
- The PMS program for the CV-3230/S SSFC as outlined on MIP [illegible] does not meet the equipment requirements as outlined in the equipment technical manual (NAVSEA 0962-[illegible]) and MIL-[illegible] for electronic equipment cooling systems.
- Parts usage data indicate that the spare parts provisioning and shipboard allowable spares for the CV-3230/S SSFC are inadequate to support the equipment; a complete review of the APL [illegible] is required to ensure that adequate support is provided during the operating cycle.
- Class B overhauls will be required on the CV-3230/S SSFC [illegible] until the time that equipment is replaced under [illegible].
- The input power and control circuitry wiring should be corrected to provide power to the cooling water circulating pump at all times.
- Numerous INSURV discrepancies remain outstanding and require correction.

4.2 RECOMMENDATIONS

Recommendations for corrective action and improvement of equipment maintenance are categorized as follows:

- ROH requirements
- Intracycle maintenance requirements
- PMS changes
- Integrated logistics support improvements
- Reliability and maintainability improvements

Tables 4-1 and 4-2 summarize the recommendations resulting from the analysis.

Table 4-1. SUMMARY OF RECOMMENDED ROH AND INTRACYCLE MAINTENANCE REQUIREMENTS FOR DD-963 CLASS, CV-3230/S SOLID-STATE STATIC FREQUENCY CONVERTERS

Recommendation	Level of Maintenance	Periodicity of Maintenance	Engineered or Qualified	Section Reference
Chemically clean, hydrostatically test, and repair, as required, the pure water cooling loop of the CV-3230/S, SSFC	Depot	ROH	E	3.7
Accomplish Class B overhaul on CV-3230/S, SSFC	Depot	ROH	E	3.8

Table 4-2. SUMMARY OF RECOMMENDED IMPROVEMENTS FOR DD-963 CLASS CV-3230/S, 60/400 Hz, SOLID STATE STATIC FREQUENCY CONVERTERS

Recommendations	Section Reference
PMS Changes	
Add the following requirements to the PMS program for the CV-3230/S, SSFCs (MIP EL-5/188) (W-1) Clean and inspect cooling system pure water strainer (M-1R) Check and adjust if required, the voltage and phase balance Note: Accomplish monthly and upon replacement of one or more of the quasi-generator P/Cs (Q-1) Test operation of thermostat and mixing valve assembly (Q-2) Test operation of system flow switch (S-1R) Clean conductivity sensors; Test conductivity meter; and Test conductivity sensors Note: Accomplish semiannually, and when malfunction is suspected (S-2) Test parallel operation of converters (A-1) Clean and inspect fresh and distilled water heat exchangers (C-1) Submit work request to repair activity to chemically clean, hydrostatically test, and repair as required, the pure water cooling loop and heat exchangers	3.7
Integrated Logistics Support Improvements	
Install all ECPs in CV-3230/S, SSFCs, at Great Lakes Naval Training Center used in conjunction with the 60/400 Hz Power Converter Course (A-652-077), and provide information on completed and proposed ECPs on subject equipment to cognizant training center personnel for updating of course and course materials	3.4.2.2
[illegible] and distribute a periodic information bulletin to provide shipboard technicians with information on current troubleshooting, repair, other maintenance techniques, and techincal data on the CV-3230/S SSFCs	3.6
[illegible] procedures for identification of P/C assemblies that need to be purged from the supply system as a result of ECP changes	3.4.4.4
Identify the "best cartridge" for use in the CV-3230/S, SSFC, pure water cooling loop, and inform all DD-963 Class ships of the appropriate NSN for this cartridge	3.4.4.5
Reliability and Maintainability	
[illegible] DD963-0247K, 400 Hz Converter Replacement as soon as practicable. In the interim, accomplish the 60/400 Hz Converter Phase I changes on DD-963 through DD-973; Phase II changes on all DD-963 through DD-973; Phase II changes on all DD-963 Class ships during each ship's next SRA; and Phase I and II changes on DD-980 through DD-990 during each ship's respective PSA.	3.4.1
[illegible] a means of identifying completed ECPs on individual CV-3230/S equipment.	3.4.2.3
[illegible] technical manual to reflect current ECP status	3.4.2.3
[illegible] further study regarding connection of frequency converters to ship's service 60 Hz power via ABTs vice MBTs	3.6
[illegible] the cooling water circulating pump of the CV-3230/S to ship's service 60 Hz power independent of equipment manual reset circuitry	3.6
[illegible] provisions in 400 Hz Converter Room No. 1 (01-188-01-O) and 400 Hz Converter Room No. 2 (01-240-0-O) [illegible] all DD-963 Class ships [illegible] shipboard technicians in the removal and replacement of the half-bridge assemblies and other heavy components of the SSFCs	3.8

SELECTED REFERENCES

The specific sources of information used as a basis for the system maintenance engineering analysis of the 60/400 Hz static frequency conversion and distribution system are as follows:

1. Generation IV MDS parts and maintenance data for the period 20 September 1975 through 30 September 1979.
2. CASREP narrative summaries for the period 1 September 1975 through 30 November 1979.
3. Technical Manuals:
   a. Ship Information Book for the DD-963 Class Ship, Volume 3, Part 1, Power and Lighting Systems: General Description and Design Information of Systems - NAVSEA 0905-LP-496-2040.
   b. Installation, Operation, Maintenance and Repair Instructions with Parts List, CV-3230/S Converter, Frequency, Static, NAVSEA 0962-LP-077-4010.
   c. 400 Hz Power Distribution Switchboard, NAVSEA 0962-LP-077-3010.
   d. VFM-3, Monitor, Voltage and Frequency, NAVSEA 0963-LP-028-7010.
   e. VM-3, Monitor, Voltage, 400 Hz, 3 phase, NAVSEA 0963-LP-014-2010.
4. Maintenance Engineering Analyses, K041A, CV-3230/S, Converter, Static Frequency.
5. PERA (CRUDES) Standard Authorized Ship Alteration and Repair Package (SARP) or USS SPRUANCE (DD-963), issued 4 March 1980.
6. Allowance Parts List (APL) 112700002C for the CV-3230/S, Converter, Solid-State Static Frequency.
7. Maintenance requirement cards (MRCs) and other Planned Maintenance System (PMS) materials as listed on the following Maintenance Index Pages (MIPs):

   A-160/25 Electronic Cooling Systems
   EL-5/188 Power Converter 60/400 Hz
   EL-5/197 Power Converter 60/400 Hz
   EL-5/210 Power Converter 60/400 Hz
   EL-5/211 Power Converter 60/400 Hz Level 4 - Equipment Test

8. Curriculum outline for 60/400 Hz Power Converter Course, A-652-0077, March 1977.

9. Instructor's Guide for 60/400 Power Converter Course, A-652-0077, May 1977.

10. U.S. Navy/Ingalls DD-963 Critical Design Review for 60/400 Hz, 187.5 kVA Static Frequency Changes, 18, 19 January 1977, Teledyne Inet.

11. Final Technical Report, CASREP Analysis, DD-963 Class 60/400 Hz Frequency Converters, prepared for Naval Sea Systems Command, (Code 5443) under Contract N00024-77-C-4758, Task 6110-1196.39.

12. David W. Taylor Naval Ship Research and Development Center Reports

  a. TM-28-78/315 Investigation of Corrosion Failures in the Cooling System of 60/400 Hz Static Frequency Converts for DD-963 Class Ships, by E. B. Bieberich.

  b. TM-28-79/47 Corrosion Inspection of Cooling Systems for 60/400 Hz Static Frequency Converters Aboard USS STUMP and USS ARTHUR W. RADFORD, by E. B. Bieberich.

  c. TM-28-79/200 Corrosion Inspection of Cooling System for 60/400 Hz Static Frequency Converters Aboard USS ELLIOT, USS DAVID R. RAY, and USS O'BRIEN.

  d. TM-28-79/210 Corrosion Inspection of Cooling Systems for 60/400 Hz Static Frequency Converters Aboard USS HEWITT, USS KINKAID, and USS MERRILL.

13. DD-963 Class Advisory Messages

  a. 38-77; 60/400 Hz SSFC Deionizer/Filter Cartridges, COMNAVSEASYSCOM Washington, D.C. message 021559Z, May 1977.

  b. 1-79; 60/400 Hz Static Frequency Converter (SFC) Status, COMNAVSEASYSCOM Washington, D.C. message 052156Z, January 1979.

14. Type Commander's COSAL, SURFLANT, and SURFPAC, dated 24 April 1979 and 25 June 1979, respectively.

15. Shipalt briefs and SAMIS shipalt information.

16. DD-963 Class Item Document.

17. Ships Systems Staging Diagram for DD-963 Class Ships, ARINC Research Publication 1844-01-1-1912, April 1979.

18. Review of Existing Maintenance and Logistics Plans for DD-963 Class Ships, ARINC Research Publication 1663-02-1-2072, November 1979.

19. Results of ship visits by ARINC Research representatives to USS YOUNG (DD-973) on 14 January 1980, USS RADFORD (DD-968) on 15 January 1980, USS STUMP (DD-978) on 16 January 1980, USS PETERSON (DD-969) on 5 February 1980, USS CARON ([illegible]) on 6 February 1980, USS MERRILL (DD-976) on 21 February 1980, and USS HILL (DD-986) on 22 February 1980.

APPENDIX A

CONFIGURATION OF THE MAJOR EQUIPMENTS OF THE DD-963 CLASS 60/400 HZ POWER CONVERSION AND DISTRIBUTION SYSTEM

Table A-1 presents the configuration of the equipments of the DD-963 Class 60/400 Hz power conversion and distribution system.

Table A-1. DD-963 CLASS 400 HZ POWER CONVERSION AND DISTRIBUTION SYSTEM CONFIGURATION

[illegible]	APL [illegible]	Quantity by Hull Number																														
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	DD-971	DD-972	DD-973	DD-974	DD-975	DD-976	DD-977	DD-978	DD-979	DD-980	DD-981	DD-982	DD-983	DD-984	DD-985	DD-986	DD-987	DD-988	DD-989	DD-990	DD-991	DD-992	DD-997
SWAB Group 314-4 400 Hz Solid-State Static Power Supplies																																
[illegible]	[illegible]		3	3	3	[illegible]	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
SWAB Group 324-1 400 Hz Switchboards																																
4[illegible] Hz [illegible] board [illegible]	[illegible]	[illegible]	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4[illegible] board [illegible]	[illegible]	[illegible]	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
[illegible] Indicator	[illegible] 4[illegible]	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	[illegible]	3	3	3	3	3	3	3	3	3	3	3	3	3
[illegible] Indicator	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8	8	8	8	8	[illegible]	8	[illegible]	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
A,BA[illegible] Circuit Breaker	14[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8	8	[illegible]	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
A,BAI 1 Circuit Breaker	14[illegible] 7	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
A,BAI 1 Circuit Breaker	14[illegible] 71	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32
A,BL[illegible] Circuit Breaker	14[illegible]			[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
SWAB Group 324-4 400 Hz Protective Devices																																
[illegible]	[illegible]	[illegible]	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
[illegible] Voltage and Fre- quency Monitor	[illegible]	[illegible]	[illegible]	[illegible]	2	2	[illegible]	[illegible]	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

APPENDIX B

MDS DATA ANALYSIS FOR THE DD-963 CLASS CV-3230/S SOLID-STATE STATIC FREQUENCY CONVERTER

Table B-1 summarizes MDS-reported malfunction and deferral codes, distribution of man-hours, and parts dollars expenditures for the CV-3230/S solid-state static frequency converter.

Table B-2 is an explanation of the column headings used in Table B-1.

Table B-[illegible]. [illegible] SUMMARY FOR [illegible], 60/400 HZ, SOLID-STATE STATIC FREQUENCY CONVERTER (APL 112700002C)

Reported Maintenance Burden

[illegible]	[illegible]	Total JCNs Reported	Ship's Force Man-Hours	IMA Man-Hours	Total Man-Hours	Parts Cost (Dollars)
[illegible]	[illegible]	[illegible]	[illegible],878	184	10,062	385,578

Distribution of Man-Hours

[illegible]	Ship's Force															IMA									
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51+	Total	0	1-5	6-10	11-15	16-20	21-30	31-40	41-50	51+	Total
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	13	[illegible]	6	[illegible]	7	5	55	514	2	4		1					2	9

Summary of Malfunctions

[illegible]	[illegible] Reported								When Discovered								Status				Priority			
[illegible]	[illegible]	[illegible]	[illegible]	4	[illegible]	6	7	[illegible]	1	2	3	4	5	6	7	0	1	2	3	0	1	2	3	4
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	37	[illegible]	[illegible]	27	167	1	[illegible]	0	14	130	104	42	41	42	117	107	37
[illegible]		[illegible]			[illegible]	[illegible]	1	13	13	[illegible]	[illegible]	24	6	[illegible]	1	2	60	38	20	16				

Summary of Deferrals and Actions Taken

[illegible]	[illegible]										Type Availability					Action Taken						
[illegible]				3	[illegible]	[illegible]	[illegible]	8	[illegible]	[illegible]	1	2	3	4	0	1	2	3	4	5	6	0
[illegible]	[illegible]		[illegible]			[illegible]	4	[illegible]	[illegible]	76	[illegible]	[illegible]	23	[illegible]	39	68	56	31	3	3	0	13
[illegible]																147	30	17	0	0	0	0
[illegible]																4	0	2	1	0	6	0

* [illegible]

Table B-2. EXPLANATION OF CODES USED IN TABLES B-1 AND B-2

Summary of Malfunctions

Code	Description
	Cause Reported
1	Abnormal environment
2	Manufacturer/installation defects
3	Lack of knowledge or skill
4	Communication problems
5	Inadequate instruction or procedure
6	Inadequate design
7	Normal wear and tear
0	Not applicable (no malfunction, or other)
	When Discovered
1	Lighting-off or starting
2	Normal operation
3	Operability tests
4	Inspection
5	Shifting operational modes
6	PMS
7	Securing
0	Not applicable
	Status
1	Operational
2	Nonoperational
3	Reduced capability
0	Not applicable
	Priority
1	Mandatory
2	Essential
3	Highly desirable
4	Desirable

Summary of Deferrals and Actions Taken

Code	Description
	Deferral Reason
1	Ship's force workload or operational priority
2	Lack of material
3	No formal training on this equipment
4	Inadequate formal training on this equipment
5	Inadequate school practical training
6	Lack of facilities or capabilities
7	Not authorized for ship's force accomplishment
8	For ship's force overhaul or availability work list
9	Lack of technical documentation
0	Other, or not applicable
	Type Availability (Requested)
1	Depot
2	IMA
3	TSU
4	Ship's force
0	Not applicable
	Action Taken
1	Maintenance action completed; parts drawn from supply
2	Maintenance action completed; parts not drawn from supply
3	Maintenance action completed; no parts required
4	Canceled
5	Configuration change
6	Rejected work request
0	Other

[illegible] SOLID-STATE FREQUENCY CONVERTERS

ECP No.	Title	Note No.	ECP No.	Title	Note No.	ECP No.	Title	Note No.
1	[illegible]		31	N/A		61	N/A	
[illegible]	[illegible]		32	N/A		62-1	Parallel Shutdown Protection	
[illegible]	[illegible]		33	PCB Receptacle		62-2	Spike and Transient Test	
4	N/A		34	Control Logic PCB Modification		63-1	Convert to Chilled Water	
[illegible]	[illegible]		35	Capacitor Retaining Straps		63-2	Shell and Tube Heat Exchanger	
[illegible]	N/A		36	N/A		63-3	N/A	
[illegible]	Air [illegible]		37	N/A		63-4	Relocate Heat Exchanger, Improve Top Piping	
[illegible]	EWI		38	N/A		64-1	Remove Spot Coolers	
[illegible]	[illegible]		39	Test Procedure Change		65-1	Add Conductivity Meter	
[illegible]	Transformer Bolt		40	N/A		65-2	Alarm to CSS	
11	[illegible]		41	Electrolysis Fix		65-3	Drain and Flush Valves	
[illegible]	[illegible]		42	Electrolysis Fix		65-4	N/A	
[illegible]	[illegible]		43	[illegible]		65-5	N/A	
14	[illegible]		44	N/A		65-6	Fill Port Strainer	
[illegible]	N/A		45	[illegible]		65-7	Mixed Bed Cartridge	
[illegible]	[illegible]		46	Inverter [illegible] Driver PCB Modification		66	N/A	
[illegible]	[illegible]		47	Upper Assembly Water System		67	N/A	
[illegible]	[illegible]		48	Half Bridge, Water System		68	N/A	
[illegible]	[illegible] Assembly		49	[illegible]		69	N/A	
[illegible]	[illegible]		50	Deionizer Level Barrier Restriction		70	Control Logic PCB Modifications	2
[illegible]	[illegible]		51	Interface Wiring Drawing Modification		71	Circuit Breaker Trip Control PCB Modification	2
[illegible]	N/A		52	Upper Half-Bridge Insulation		72	Deionized Water Temperature Switches	2
[illegible]	[illegible]		53	N/A		73	N/A	2
[illegible]	[illegible]		54	N/A		74	N/A	2
[illegible]	N/A		55	N/A		75	Relocate Conductivity Meter	2
[illegible]	N/A		56	N/A		76	Water Cooled Modifications	3
[illegible]	[illegible]		57	N/A		77	Air Cooled Development	4
[illegible]	N/A		58	N/A		78	Air Cooled Production	4
[illegible]	[illegible]		59	Accumulator Sight Glass		79	Water Cooled Modification Production	
[illegible]	[illegible]		60	Condition Monitor Sensor Relocation				

NOTES:

1. [illegible] through [illegible] have been accomplished on all commissioned DD-963 class ships
2. [illegible] 400 Hz Converter Phase I change
3. [illegible] 400 Hz Converter Phase II change
4. [illegible]

APPENDIX D

DD-963 CLASS ADVISORY NUMBER 38-77

This appendix is a reproduction of DD-963 Class Advisory Number 38-77.

ROUTINE

R 021559Z MAY 77

FM COMNAVSEASYSCOM WASHINGTON DC

TO AIG NINE NINE THREE FIVE
COMNAVSURFPAC SAN DIEGO CA
COMNAVSURFLANT NORFOLK VA

INFO CHNAVMAT WASHINGTON DC
NAVSEACENPAC MARE ISLAND CA
NAVSEC WASHINGTON DC
NAVSEACENLANT PORTSMOUTH VA
COMNAVSUPSYSCOM WASHINGTON DC

UNCLAS E F T O //N04408//

DD963 CLASS ADVISORY NO 38-77: 60/400 HZ SSFC DEIONIZER/ FILTER CARTRIDGES

1. THE FOLLOWING DEIONIZER/FILTER CARTRIDGES ARE CURRENTLY USED IN 60/400 HZ CONVERTER AND ELECTRONIC COOLING LOOP APPLICATIONS IN DD963 CLASS DESTROYERS:

A. DEIONIZER CARTRIDGE (FILTER UNIT) FOR 60/400 HZ CONVERTER, COLOR CODED ORANGE PN30C241, MFG BY TELEDYNE (FSCM33047), NSN 9C4610-01-012-3461, COST $130.

B. MIXED BED CARTRIDGE FOR 400 HZ CONVERTER, COLOR CODED RED TYPE MR-1, MFG BY VARONICS, FSN 4610-00-712-9394, APPROXIMATE COST $150.00.

C. MIXED BED CARTRIDGE FOR ELECTRONIC COOLING LOOP, COLOR CODED GREEN, PN 600040 MFG BY PARAMATIC (FSCM 25204), NSN 9C4610-00-460-7015, COST $39.21.

D. OXYGEN REMOVAL CARTRIDGE FOR ELECTRONIC COOLING LOOP, COLOR CODED BLACK, PN600039, MFG BY PARAMATIC (FSCM 25204), NSN 9C 4610-00-460-7020, COST $43.37.

E. ORGANIC FILTER FOR ELECTRONIC COOLING LOOP, COLOR CODED RED, PN600042, MFG BY PARAMATIC (FSCM 25204), NSN 184610-01-026-1745, COST $35.00.

2. THE MIXED BED CARTRIDGE USED IN THE ELECTRONIC COOLING LOOP (ITEM 1C ABOVE) IS INTERCHANGEABLE WITH THE DEIONIZER CARTRIDGE (ITEM 1Z ABOVE) AND THE MIXED BED CARTRIDGE (ITEM 1B ABOVE) USED ON THE 400 HZ CONVERTER. IN CONJUNCTION WITH PRESENT ENGINEERING CHANGES BEING PROPOSED IN THE 400 HZ CONVERTERS BASED ON CRITICAL DESIGN REVIEW FINDINGS, ADOPTION OF A COMBINED BED CARTRIDGE WITH DEIONIZER AND OXYGEN SCAVENGER QUALITIES IN LIEU OF THE DEIONIZER AND MIXED BED CARTRIDGES (ITEMS 1A AND 1B) IS BEING INVESTIGATED.

3. IN THE INTERIM, USE OF THE MIXED BED CARTRIDGE (ITEM 1C ABOVE) IS AUTHORIZED IN LIEU OF THE PRESENT DEIONIZER CARTRIDGE (ITEM 1A ABOVE) WHEN THE LATTER CARTRIDGE REQUIRES REPLACEMENT.

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APPENDIX E

OUTSTANDING INSURV DISCREPANCIES ON THE CV-3230/S SOLID-STATE STATIC FREQUENCY CONVERTER

Table E-1 presents a list of outstanding INSURV discrepancies on the DD-963 Class CV-3230/S 60/400 Hz solid-state static frequency converters.

Table E-1. OUTSTANDING INSURV DISCREPANCIES ON THE DD-963 CLASS CV-3230/S 60/400 HZ SOLID-STATE STATIC FREQUENCY CONVERTERS

Item	Discrepancy
1	Because of the past high failure rate of DD-963 Class converters and results of Design Review, these converters are considered unreliable for sustained operation in wartime, or peacetime.
2	Conductivity cells do not accurately indicate the conductivity of deionized water.
3	60/400 Hz converter parallel operation is very unreliable and is not used.
4	Indicator lights for 60/400 Hz converters at EPCE ( ) do not indicate which converter is carrying the 400 Hz load.
5	No deck drains or bilge alarms are provided in converter rooms.
6	There are no provisions in the equipment or converter spaces to assist in the removal of half-bridge assemblies and other heavy components.
7	The compactness of the units requires exact and precise positioning of connections to prevent internal equipment shorts.
8	Small resistors located on the P/C boards near the cannon-plug connections on half-bridge assemblies are not protected and are repeatedly being broken off during removal and replacement of half-bridge assemblies.
9	Various connections, capacitors, and check points cannot be reached, because panels cannot be readily removed for access.
10	The test points provided on the converters are inadequate for proper troubleshooting and repair of units.

(continued)

Table E-1. (continued)	
Item	Discrepancy
11	There is no means of ascertaining the ECPs that have been completed on individual units, e.g., no ECP identification plates installed on units.
12	Upper panels on front cover are not hinged to facilitate main maintenance.
13	Single-phase current-limiting is not provided for in converters.
14	Doors on units do not close properly, because of misalignment of door captive screws.
15	Voltage adjustments of units IRS1-A and IRS1-B require two people because of the location of the switchboard mounted voltmeters.
16	During converter cool-down, deionized water system hoses leak because of the difference in expansion and contraction rates between metal tubing and hoses.
17	Newly installed heat exchangers require a minimum of one air-conditioning unit and two chilled water pumps to provide proper flow for heat dissipation.
18	Ships report a high failure rate of input and output transformers.
19	Supply support for the installed 60/400 Hz converters is extremely poor and requires long delays for receipt of repair components.

APPENDIX F

DD-963 CLASS ADVISORY NUMBER 1-79

This appendix is a reproduction of DD-963 Class Advisory Number 1-79.

ROUTINE

R 052156Z JAN 79

FM COMNAVSEASYSCOM WASHINGTON DC

TO COMNAVSURFPAC SAN DIEGO CA COMNAVSURFLANT NORFOLK VA

INFO AIG NINE NINE THREE FIVE DTNSRDC ANNAPOLIS MD
SPCC MECHANICSBURG PA NAVSEC WASHINGTON DC

UNCLAS //N09030//

DTNSRDC/A PASS TO CODE 2813
DD-963 CLASS ADVISORY NO. 1-79; 60/400HZ STATIC FREQ CONVERTER (SFC) STATUS

A. COMNAVSEASYSCOM WASHINGTON DC 101818 OCT 78: ADV NO. 44-78
B. NAVSHIPS 0962-077-4010 60/400HZ SFC TECH MANUAL

1. REF A IS CANCELLED. PERTINENT ACTIONS REQUIRED BY REF A ARE INCORPORATED IN THIS ADVISORY. NOTE THAT IF THE ONE TIME CHECKS CALLED FOR IN THIS ADVISORY WERE ACCOMPLISHED BY ADVISORY 44-78, THEY NEED NOT BE REPEATED.

2. THE 60/400HZ STATIC FREQUENCY CONCERTERS ON SPRUANCE CLASS DESTROYERS HAVE BEEN RETROFITTED TO ELIMINATE SALT WATER COOLING AND TO PROVIDE IMPROVED WATER CONDUCTIVITY MONITORING, AMONG OTHER CHANGES. RESULTS TO DATE ARE NOT FAVORABLE. OF FOUR SHIPS SURVEYED AFTER CONVERTER MODIFICATIONS, TWO INDICATE NO CORROSION IN THE DE-IONIZED WATER COOLING LOOP AND TWO SHIPS DISPLAY CORROSION RANGING FROM INCIPIENT TO COMPLETE FAILURE. TO MAINTAIN UNITS OPERATIONAL, CONTINUED MONITORING AND CAREFUL CONTROL IS REQUIRED UNTIL FURTHER CHANGES CAN BE ACCOMPLISHED.

3. CURRENT ACTIONS REQUIRED ARE:

A. WEEKLY CHECK OF CONDUCTIVITY OF DEIONIZED WATER. TAKE SAMPLE FROM LOW POINT DRAINS OF ALL PHASES OF EACH CONVERTER. USE PORTALE METER FOR TESTS. IF CONDUCTIVITY EXCEEDS 2.0 MICROMHOS UNIT MUST BE DRAINED AND REFILLED FOLLOWING PROCEDURES IN REF B.

B. WEEKLY VISUAL CHECK OF STRAINER AT DEIONIZER PUMP OUTLET, CLEAN AS NECESSARY.

C. ONE TIME CHECK OF FITTING TO DETERMINE IF OBSTRUCTION EXISTS IN WAY OF HOSE CONNECTION FITTING AND TUBING WELD. IF OBSTRUCTION EXISTS SUBMIT WARRANTY/GUARANTEE TWO KILO OR WORK REQUEST (POST SCN).

D. CHECK TO INSURE THAT NYLON BRAID (HOSE REINFORCEMENT) IS PHYSICALLY SEPARATED FROM ALUMINUM TUBING. SEPARATE AS NEEDED.

E. ONE TIME CHECK AND ON REPLACEMENT INSURE THAT DEIONIZER CARTRIDGE IS INSTALLED PROPERLY. WATER FLOW IS THROUGH OXYGEN SCAVENGING PORTION OF CARTRIDGE FIRST. CHECK CAN BE MADE TO DETERMINE THAT THE CARTRIDGE END WITH LARGER HOLE AND SPRING IS INSTALLED FIRST (NOT ADJACENT TO PIPING CONNECTION).

F. THE INSTALLED CONDUCTIVITY METER IS MARKED PART NO. 600110-4. HOWEVER, THIS METER HAS BEEN MODIFIED BY TELEDYNE INET AND UNMODIFIED METERS ON PARTS FROM UNMODIFIED MATERS CANNOT BE USED INTERCHANGEABLY. FOR REPLACEMENT PARTS USE PART NO. 600110-5 WHICH CAN BE PROCURED FROM TELEDYNE INET. PARMATIC DOES NOT CURRENTLY HAVE THE PROPER REPLACEMENT.

G. IN ORDER TO MINIMIZE CONDENSATION PROBLEMS, IT IS RECOMMENDED THAT ALL THREE CONVERTERS BE LEFT ON LINE EVEN IF UNLOADED. THE UNIT SHOULD BE SECURED ONLY WHEN NECESSARY FOR MAINTENANCE.

H. SHOULD TWO CONVERTERS IN PARALLEL FAIL TO SHARE LOAD WITHIN THE SPECIFIED VALVE OF 15 KW, THE CONVERTER PHASES SHOULD BE BALANCED. PROCEDURE FOR BALANCING IS PROVIDED IN REF B.

I. WHERE WIRES WITHIN THE CONVERTERS HAVE FRAYED INSULATION DUE TO MOVING SUBASSEMBILIES OR OTHER RELATED ACTIONS THE INSULATION SHOULD BE REPAIRED WITH HEAT SHRINKABLE INSULATION.

J. WHEN CONVERTERS ARE ON THE LINE IT IS NECESSARY TO RUN TWO CHILLED WATER PLANTS. ONLY THROUGH RUNNING TWO PLANTS CAN AN ADEQUATE CHILLED WATER FLOW RATE BE PROVIDED TO THE CONVERTERS. FOR INFORMATION AN ENGINEERING CHANGE IS BEING DEVELOPED TO PROVIDE INDEPENDENT CHILLED WATER PUMPS TO SERVICE THE CONVERTERS.

K. SOME 300 AMP OUTPUT FUSES MANUFACTURED BY INTERNATIONAL RECTIFIER HAVE A DEFICIENCY WHICH COULD CAUSE EXPLOSIVE BREAKUP OF THE FUSE WHEN BREAKING THE CIRCUIT DUE TO OVERLOAD. NOT ALL INTERNATIONAL FUSES HAVE THE PROBLEM NOR IS IT POSSIBLE TO DETECT OR IDENTIFY DEFECTIVE FUSES. IT IS RECOMMENDED THAT THE FUSES BE REPLACED AND IN THE INTERIM AVOID PLACING PERSONNEL WHERE THEY MAY BE INJURED IF A FUSE BLOWS. OTHER MANUFACTURER'S FUSES ARE NOT KNOWN TO HAVE THIS PROBLEM.

4. FUTURE EFFORT PLANNED INCLUDES:

A. DEVELOP AND PROMULGATE MAINTENANCE AND CALIBRATION PROCEDURES FOR THE INSTALLED CONDUCTIVITY METERS (WITHIN 30 DAYS).

B. PROCEDURES FOR IDENTIFICATION OF PRINTED CIRCUIT CARDS WHICH NEED TO BE PURGED FROM THE SUPPLY SYSTEM AS A RESULT OF RE-

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COMNAVSEASYSCO

TROFIT CHANGES (WITHIN 30 DAYS).

C. ISSUE REVISED TECHNICAL MANUAL (ABOUT 60 DAYS).

D. DEVELOP CHANGES TO ELIMINATE ALUMINUM IN THE DEIONIZED WATER COOLING CIRCUIT AND ADD CHILLED WATER CIRCULATING PUMPS. (LONG TERM, AT LEAST NINE MONTHS BEFORE IMPLEMENTATION).

BT

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